COMPACT THREE-AXIS RING LASER GYROSCOPE

BACKGROUND

1. Field of the Invention

The present invention relates to intertial sensors. More particularly, this invention pertains to the compact design for a triaxial ring laser gyroscope of the multioscillator type.

2. Description of the Prior Art

The multioscillator has been proposed as a means for overcoming the "lock-in" problem in ring laser gyroscopes. As is well known, lock-in refers to the tendency of counterpropagating beams to lase at a single frequency, or lock point, at low input rotation rates. As such, ring laser gyroscopes are essentially insensitive to rotation rates below known characteristic thresholds. The range of input rates over which the gyro gives no output is known as the "dead band". One common means of overcoming this insensitivity is known as mechanical dither and involves the application of a bounded oscillatory motion to the gyro frame. In this way, the gyro is continually swept through the deadband and the effects of lock-in are greatly reduced. The shortcomings of the mechanically dithered gyroscope are well recognized in the art.

In contrast, a multioscillator operates as a pair of two-mode ring laser gyroscopes sharing a single cavity. The multioscillator light cavity sustains a substantially left circularly polarized (LCP) beam pair, comprising one beam circulating in the clockwise direction and the other in the counterclockwise direction, as well as a substantially right circularly polarized (RCP) counterpropagating beam pair. Ideally, each beam pair acts independently as a two-mode ring laser gyroscope and senses body rotation by means of the Sagnac effect.

In order to achieve independent operation of the two gyroscopes within the same cavity, the LCP beam pair must be separated in frequency from the RCP beam pair. This separation, known as "reciprocal splitting" is typically on the order of a few hundred MHz. By employing a non-planar light path that produces different round-trip phase shifts for LCP and RCP light and, thus, different lasing frequencies, the required reciprocal splitting may be accomplished without the use of lossy active intracavity elements.

Each of the LCP and RCP gyros, while operating independently of one another, is, however, still subject to the lock-in phenomenon. A second bias, known as "nonreciprocal splitting" is imposed for overcoming the lock-in effect. Nonreciprocal splitting is commonly accomplished by introducing a Faraday rotation into the cavity. When circularly polarized light passes through a Faraday rotator, it experiences a phase shift that depends upon the direction of propagation through the rotator. As such, the clockwise and counterclockwise beams of the LCP and RCP gyros experience different phase shifts and thus lase at different frequencies. Typical values of nonreciprocal splitting in a multioscillator are much smaller (about 1 MHz) than reciprocal splitting values. Nonreciprocal splitting may be achieved by means of an intracavity element of suitable glass mounted within an axial magnetic field as taught by the United States patent of Andringa, U.S. Pat. No. 3,741,657 entitled "Differential Laser Gyro System". Another approach involves surrounding the gaseous gain medium of the cavity with an axial magnetic field as described in U.S. Pat. No. 4,229,106 of Dorschner et al. for "Electromagnetic Ring Resonator".

When nonreciprocal splitting is applied to the multioscillator in the prescribed manner, the resulting bias shift in the

left circularly polarized gyro is equal but opposite in sign to the bias shift in the right circularly polarized gyro. Thus, when the outputs of the two gyros are summed, the resultant signal is doubly sensitive to body rotation but independent of the magnitude of the applied bias. In this way, the differential nature of the multioscillator makes it inherently insensitive to bias variations that can be caused, for example, by changes in the magnetic field, temperature or the like, which have proven to be major problems in single gyro, two-mode designs that utilize a d.c. bias.

Propagation systems must measure space-dependent variables, such as rotation, with respect to (or about) a set of three orthogonal axes. The design of a three-axis multioscillator or, in fact, any ring laser, that is sufficiently compact and realizable in a manufacturing sense is beset by numerous difficulties. In the operation of a ring laser, the chosen fill gas(es) necessarily interact with electrical fields to produce the desired lasing action. Thus, the design of any ring laser gyroscope must provide for the positioning of anodes and cathodes in addition to locating mirror faces and internal bores.

U.S. Pat. No. 4,795,258 of Martin entitled "Nonplanar Three-Axis Ring Laser Gyro With Shared Mirror Faces" teaches triaxial multioscillator designs that feature glass block gyro frames bounded by a plurality of planar surfaces which enclose three intersecting nonplanar cavities. Each cavity consists of four equal segments or bores for measuring rotation about three orthogonal axes. The patent discloses two configurations, one based upon a regular octahedron that is truncated to form a fourteen-sided frame and the other being a rhombic dodecahedron comprising twelve planar surfaces. Each of the designs taught by that patent improves upon prior triaxial multioscillators by offering a substantial reduction in the required number of electrodes. By minimizing the number of electrodes, the devices achieve advantages over, for example, the United States patent of Styles et al. (U.S. Pat. No. 4,477,188) that requires six anodes and two cathodes and that of Simms (U.S. Pat. No. 4,407,583) that requires six anodes and a single cathode. This leads to gyros of smaller cavity lengths as smaller frames are possible when one reduces the possibility of undesired interactions between surface-mounted electrodes.

While the device disclosed in the Martin patent represents an improvement, each of the embodiments taught by it is limited in terms of possible size reduction or miniaturization by the presence of intracavity Faraday rotators. Such a rotator typically comprises an exterior "doughnut" of magnetic material that is filled with glass. The disk-like rotator is mounted within each of the three non-planar cavities. The segment of a cavity into which the rotator is fixed includes a discontinuity in diameter that forms an annular shoulder. The gyro is assembled by pushing the rotator through the enlarged diameter portion of the appropriate cavity segment until it abuts the annular shoulder. The periphery of the rotator is then bonded to the annular shoulder by means of an appropriate agent such as indium.

Both of the multioscillator configurations of the Martin patent are suitable for gyro cavity lengths of about fifteen centimeters or more. While providing a model that is theoretically capable of functioning at even smaller cavity lengths, both of the configurations encounter manufacturing difficulties when one attempts to realize designs of lesser cavity length. This is quite unfortunate as many applications place a premium upon compactness. For example, military applications involving pointing, tracking and target discrimination accomplished by unmanned aerial vehicles, seeker missiles, small satellites, platforms for laser communications and synthetic aperture radar place a premium upon compactness.